FINAL
ANALYSIS OF THE POTENTIAL BENEFITS OF RECYCLED WATER USE IN DYE HOUSES

Prepared for:

Central Basin
Municipal Water District

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WATER WASTEWATER RECYCLED WATER

1.0 INTRODUCTION

Central Basin Municipal Water District (CBMWD or Central Basin) is a public agency with a 227 square mile service area governed by 5 publicly elected directors. CBMWD purchases imported water from the Metropolitan Water District of Southern California (METROPOLITAN) and recycled water from the Los Angeles County Sanitation District (LACSD) and wholesales the imported and recycled water to cities, mutual water companies, investor-owned utilities, and private companies. CBMWD serves a population of 1.5 million people living within 24 cities in southeast Los Angeles County, as well as unincorporated County areas.

The textile dyeing industry represents a significant potential for increased recycled water use in Central Basin and neighboring West Basin Municipal Water Districts. Textile finishing processes are very water-intensive and, as a result, these facilities are some of the largest industrial water users in Central Basin. There are more than 20 textile dyeing and finishing facilities within the two service areas with a potential demand estimated to be greater than 7,000 afy. Conversion of these facilities to the recycled water supply would result in a significant savings of potable water.

In an effort to examine the viability of recycled water use among fabric dyers, this paper reviews the dye processes, attempts to quantify the potential water savings to be expected from the conversion to recycled water, investigates the water quality requirements for a successful conversion, discusses the benefits of the use of recycled water and identifies potential issues pertaining to the wide-scale implementation of recycled water use in the dye industry in Southern California.

2.0 BACKGROUND

In response to increasing demands for water, limitations on imported water supplies and the threat of drought, Central Basin developed a regional water recycling program in the early 1990s. The Central Basin Recycled Water Project delivers approximately 4,000 acre-feet of recycled water annually to more than 150 industrial, commercial, and landscape irrigation sites. Central Basin's use of recycled water augments the precious groundwater and imported water supplies of southeast Los Angeles County.

In the past, the District’s short-range marketing strategy for the recycled water customer development program was largely targeted at irrigation sites. However, proposed recycled water projects planned by CBMWD within the Cities of Vernon, Montebello, and Commerce have defined the District’s present and future direction of its long-range marketing plan. The new strategy identifies a significant target “market shift” from the traditional irrigation targets to a more complex and business orientated industrial target market.

The District, in order to benefit from the market shift, must market recycled water to its customer base as a “product” and not simply a conservation tool. Although industrial sites provide Central Basin with a significantly higher water demand within a given area and year-round use, the process of connecting industrial sites is much more complex with respect to business economics, engineering, regulation (State, County and City) and water quality.

Several carpet-dyeing installations in Southern California have been successfully using recycled water in their operations for a number of years. Fabric dyers have not viewed the success of the carpet dyers with recycled water as indicative of the applicability to their industry. Fabric dyers use many more cloth types than carpet manufacturers and very little color variation between batches can be tolerated.

3.0 TEXTILE DYEING PROCESS

It is important to understand the processes employed by the dye houses, the quantities of water used and the water quality requirements that need to be met to determine the feasibility of the conversion of dye houses to recycled water.

3.1 Overview

For a dye house to turn grey goods into a finished product, several sequential steps must occur, including fabric preparation, dyeing, printing and finishing. Of all the fabric finishing unit processes; scouring, bleaching, dyeing and finishing are the most water-intensive and are therefore key targets for the use of tertiary-treated recycled water. While many of these steps are performed at specialized fabric preparation or finishing facilities, some of theses operations are employed by dye houses in Central Basin and are briefly discussed in the following.

3.1.1 Fabric Preparation

Fabric preparation is a series of treatment steps to remove impurities that may interfere with the subsequent dyeing, printing and finishing processes. The preparation treatments usually include desizing, scouring and bleaching, but may also include singeing (a dry process) and mercerizing (EPA, 1997). The four wet processes are discussed here.

Desizing: Sizing agents are added to fibers in order to improve their strength and bending behavior during the weaving process. Water-soluble sizes are used for synthetic fabrics and water-insoluble starches are used for natural fibers. Once the fibers are woven, the sizing agents need to be removed from the fabric in a process called desizing. Desizing involves a hot water wash for synthetic fibers or an enzyme wash for natural fibers (EPA, 1997). It is important to remove sizing agents from natural fibers because the starches can react and cause color changes when exposed to sodium hydroxide during the scouring process (NPI, 1999).

Scouring: Scouring is performed to remove any impurities present in the fabric. The impurities (i.e. lubricants, dirt, surfactants, residual tints) are removed using an alkaline solution, typically sodium hydroxide, at high temperatures to breakdown or emulsify and suspend impurities. The specific scouring procedures vary with the type of fiber or cloth construction (NPI, 1999). Because soaps and detergents used during scouring may precipitate in hard water, process water is usually softened prior to the start of the scouring process (Hendrickx, 1995).

Bleaching: Bleaching is the removal of unwanted color from the textile fibers and typically involves the use of one of three main bleaching agents: hydrogen peroxide, sodium hypochlorite or sodium chlorite (NPI, 1999). Hydrogen peroxide bleaching is performed under alkaline conditions and, as a result, may be combined with the scouring process (Hendrickx, 1995). The bleaching process includes three main steps: (1) saturating the fabric with the bleaching agent and other necessary chemicals; (2) raising the temperature to the recommended level for the particular textile and maintaining that temperature for a set period of time; and (3) thoroughly washing and drying the fabric (NPI, 1999).

Mercerizing: Mercerization is a chemical process used to increase the dyeability, strength and appearance of cotton and cotton/polyester fabrics. The process requires passing the fabric through a solution of sodium hydroxide. The fabric is then stretched and sprayed with hot water to removed most of the caustic solution. Further removal of the sodium hydroxide solution occurs during subsequent washes while the fabric is held in tension. An acid treatment and several more washes may follow for further neutralization of any remaining hydroxide (EPA, 1997).

3.1.2 Dyeing

Dyeing adds color to fabrics through the use of several chemicals and dyestuffs, depending on the fabric and processes used. Dyeing is performed in either continuous or batch modes. In the continuous dyeing process, the fabric is passed through a dyebath of sufficient length. The dye is fixed to the fabric using chemicals or steam, then washed to remove any excess dyes and chemicals (Hendrickx, 1995). The batch dying process is similar, though the dye application stage occurs in a dyeing machine where the textile and dye solution are brought to equilibrium. The use of chemicals and/or heat optimizes the batch process (EPA, 1996). Washing also follows the batch dye application stage. Common methods of batch dyeing include jig, jet, beam and beck processing (NPI, 1999). Each dyeing process requires a different dyebath ratio, or the amount of dye needed per unit of fabric. The dyebath ratio ranges from 5 to 50 depending on the type of dye, dyeing system and fabric type (EPA, 1997).

The dyeing process can take place at different stages of the fabric development. Stock dyeing is used to dye textile fibers prior to their incorporation into yarn. Yarn dyeing, including stock, package and skein dyeing, occurs once the fibers have been spun into yarn but prior to the construction of the fabric. Piece dyeing, dyeing of assembled fabric, is the most common dyeing method because it gives the manufacturer maximum flexibility with the color of the fabric. The largest volume of piece dyeing uses the continuous methods of beck and jig dyeing. In beck dyeing, the fabric is passed in rope form through the dyebath until the desired color intensity is reached. Jig dyeing uses the same process, though the fabric is passed through the dyebath at full width rather than in rope form. Other piece dyeing methods include jet dyeing, where fabric is placed in a heated tube or column where jets of dye solution penetrate the fabric, or pad dyeing, used mostly to dye carpet (EPA, 1997). Illustrations of four dyeing methods, package, jig, jet and beck, are shown on **Figure 1**.

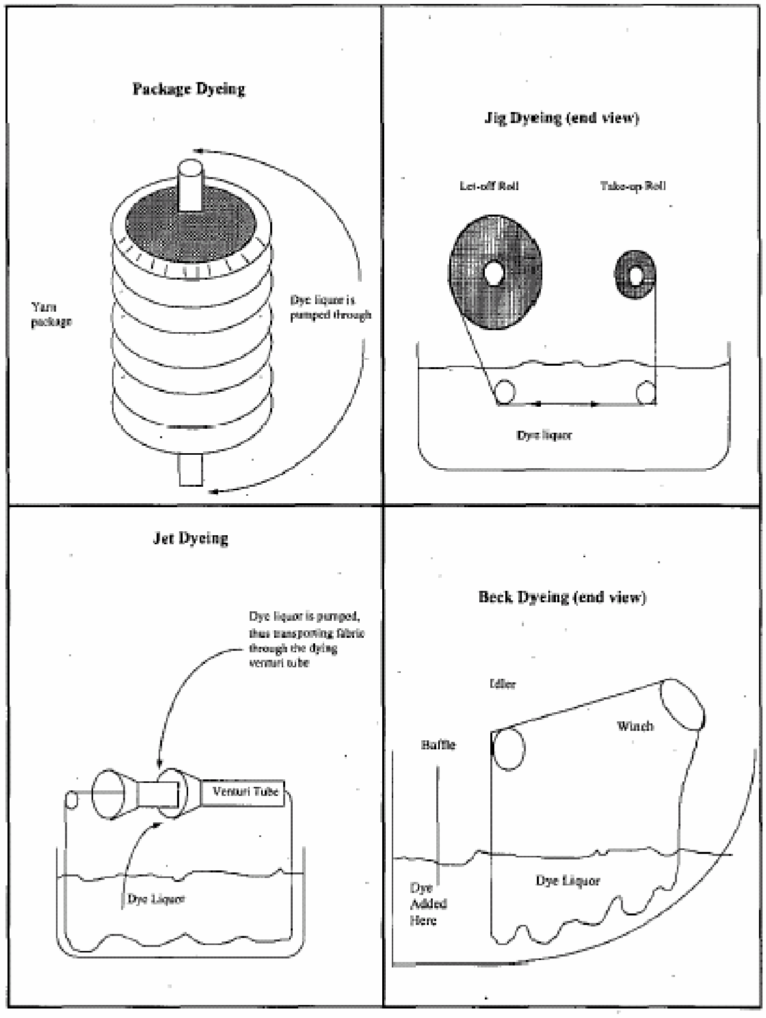

Figure 1. Common Textile Dyeing Methods. Source: EPA, 1997.

There are several different classes of dyes used in textile dyeing and printing operations. The most commonly used dyes are reactive and direct dyes for dyeing cotton and disperse dyes for dyeing polyester (EPA, 1997). Reactive dyes react with the fiber to form chemical bonds with the fiber essentially becoming part of the fiber. Direct dyes can be added to fibers “directly” without the aid of affixing agents. While reactive and direct dyes are water soluble, the low water solubility of disperse dyes requires them to be applied as a dispersion of finely ground powders in a dyebath (EPA, 1996). Disperse dyes require either heat and high pressures or dye carriers to penetrate synthetic fibers (EPA, 1997). In addition to polyester, disperse dyes are used on other synthetic fibers, such as nylon, rayon and acrylic. Other dye classes include acid dyes for wool and nylon, basic dyes for synthetics, sulfur and vat dyes for cotton and other celluosic fibers, and pigments. Pigments, unlike dyes, require binders to attach to fibers, remain insoluble during application and are typically used during printing operations, as discussed in Section 3.1.3 (EPA, 1996).

3.1.3 Printing

While dyeing is used to apply solid colors to fabrics, more intricate patterns and designs are added to fabrics during the printing step. During printing, colors are added by applying paste-like dyes or pigments (EPA, 1996). Pigments are used for 75 to 85 percent of all printing operations. As discussed in Section 3.1.2, pigments remain insoluble during application, which results in no washing steps being required and very little water waste being generated. Resin binders are used to attach pigments to fabric fibers and evaporative solvents are used to transport the pigment to the fibers (EPA, 1997).

Various techniques and machinery are used for printing. The most common technique is rotary screen printing. In rotary screen printing, the fabric passes under a series of cylindrical screens each printing a different color. Once printed, the fabric passes to a drying oven where the patterns are set. Other printing techniques are direct, discharge, resist, ink-jet and heat transfer (EPA, 1997).

3.1.4 Finishing

Finishing is performed to improve the appearance, texture or performance of a fabric (EPA, 1996). Qualities such as softness, luster, durability and sometimes water repelling and flame resistance of fabrics are increased with finishing processes. Both chemical and physical methods are used to finish fabrics (Hendrickx, 1995). Chemical methods usually involve contact of the fabric with a finishing solution after which the fabric is washed and/or dried (EPA, 1996). Chemical treatments include optical finishes, absorbent and soil release finishes, softeners and abrasion-resistant finishes and physical stabilization and crease-resistant finishes. Physical finishing involves brushing, ironing or other physical means of altering fabric. Physical treatments include heatsetting, brushing and napping, softening, optical finishing, shearing and compacting (EPA, 1997).

3.2 Water Consumption

The USEPA reports that textile wet processing typically requires between an average of 5 to 35 gallons of water for every pound of finished product produced based on the type of fabric (EPA, 1996). Water use varies considerably for different fabric types, as can be seen from **Table 1**. Water consumption also varies significantly among unit processes, as shown on **Table 2**.

Table 1
Water Use in Textile Wet Processing

Fabric Type	Water Usage (gal/lb)		
	Minimum	Median	Maximum
Wool	13.3	34.1	78.9
Woven	0.6	13.6	60.9
Knit	2.4	10.0	45.2
Stock/Yarn	0.4	12.0	66.9
Non-woven	0.3	4.8	9.9
Felted Fabrics	4.0	25.5	111.8

Source: EPA, 1996

Table 2
Water Consumption by Industry Unit Process

Process	Water Consumption (gal/lb)
Preparation:	
Singeing	0
Desizing	0.3 - 2.4
Scouring	2.3 - 5.1
Continuous bleaching	0.3 - 14.9
Mercerizing	0.12
Dyeing:	
Beam	20
Beck	28
Jet	24
Jig	12
Paddle	35
Skein	30
Stock	20
Pad-batch	2
Package	22
Continuous bleaching	20
Indigo range	1 – 6
Printing	3
Print afterwashing	13.2
Finishing:	
Chemical	0.6
Mechanical	0

Source: EPA, 1996

Dyeing is the most water-intensive of the unit processes, consuming up to 35 gallons of water per pound of finished product. A dye houses processing 50,000 pounds of fabric a day can easily use 1.75 million gallons of water per day.

3.3 Water Quality Requirements

Water quality requirements for textile wet processing are hard to define due to the different requirements for each fiber, process and final product quality. Generally, process water should have little or no chlorine, low metals content (i.e. iron and copper) and low salts concentrations (i.e. chloride and sulfate). Alkalinity, pH and color with an affinity for fabric (i.e. residual dyes) are also of concern (Smith, 2003).

The quality of water delivered to textile dyeing and finishing operations in CBMWD is usually adjusted prior to and during processing. For example, due to the desirability of low hardness for textile dyeing, dye houses typically will add softening agents to the water prior to dyeing operations or employ water softening devices. Additional chemicals may be added depending on the types of wet processing employed (i.e. dyes, pigments, bleach, sizes, mercerizes). Consistent water quality plays a very significant role in the success of textile wet processing operations so that chemical levels do not need continuous inspection, analysis and adjustments.

Dye houses within Central Basin are currently provided with potable water derived from any one of three sources: (1) State Project Water from Northern California, (2) Colorado River water, or (3) local groundwater. Each source of potable water can have significantly different water quality.

The source of potable water supply delivered by CBMWD varies seasonally, with an annual average approximately 75 percent groundwater and 25 percent imported water purchased from METROPOLITAN. At any given time, a customer in Central Basin can receive water solely from one source or as a blend of two or all three sources. As a result, the water quality characteristics of the potable supply can vary considerably.

Recycled water in Central Basin is supplied from one of two LACSD treatment plants, either the San Jose Creek Water Reclamation Plant (WRP) or the Los Coyotes WRP. The source of recycled water delivered to a particular customer is dependent on their location. Customers in the Cities of Vernon and Commerce, where most of the dye houses reside, receive almost exclusively recycled water from the San Jose Creek WRP.

The quality of recycled water produced during the year at the LACSD treatment plants is more consistent than potable water quality. This is because recycled water is derived from wastewater generated from potable water delivered to a large geographic area. The size of the area tends to buffer a lot of the variability in potable water quality that may be experienced by a specific customer.

A comparison of potable water quality and recycled water quality to State of California Department of Health Services (DHS) Drinking Water Standards is provided in **Table 3**. Primary drinking water standards are set by DHS for constituents that may adversely affect public health. Secondary drinking water standards are set by DHS for constituents that may adversely affect the taste, odor or appearance of drinking water. Potable water quality is shown for all three sources available to Central Basin retail agencies. Recycled water quality is shown for the San Jose Creek WRP since that would be the source of recycled water delivered to dye houses in CBMWD.

The variability between the three potable water sources (State Project Water, Colorado River Water and groundwater) for several of the constituents is evident in the information contained in **Table 3**. Recycled water quality is comparable to potable water quality with values below drinking water standards for all of the constituents of concern to dye processes.

As previously mentioned, consistency of water quality delivered can be of significant value to the dye houses in Central Basin. Chemical addition is often employed in the dyeing industry to adjust water quality to make it suitable for use in processing. Consistent water quality can reduce the need for continuous inspection and adjustments.

Several studies have been performed where recycled water was used for textile wet processing. While slight differences may have been noticed, none were so significant as to be unacceptable to the processing facility staff (Hendrickx, 1995). This research coincides with the results of the pilot and demonstration tests performed at General Dye and Finishing, Inc., discussed later in this paper.

Table 3
Comparison of Water Quality Values for Constituents of Concern for Dye Processes

Constituent	Unit	Drinking Water Standard	Potable Water			Recycled Water[4]
			State Project Water[1]	Colorado River Water Blend[2]	Ground Water[3]	
Alkalinity ($CaCO_3$)	mg/L	--	97	112	181	198
Aluminum[5]	mg/L	0.2	0	0.14	<0.05	NA
Chloride[6]	mg/L	250	64	76	45	116
Chlorine	mg/L	--	2	2	NA	3.7
Color[6]	mg/L	15	2	1.2	4.8	NA
Copper[6]	mg/L	1.0	<0.05	<0.05	<0.05	0.03
Heavy Metals[5]	mg/L	0.06	0	0.002	NA	NA
Iron[6]	mg/L	0.3	<0.1	<0.1	0.36	0.08
Manganese[6]	mg/L	0.05	<0.02	<0.02	0.09	0.02
pH	pH units	--	8	8.1	7.7	7.0
Sulfate[6]	mg/L	250	68	174	110	101
TSS	mg/L	--	NA	NA	NA	1.7
TDS[6, 7]	mg/L	500 – 1,000	305	487	419	569
Total Hardness	mg/L	--	147	241	227	217

Notes:
1 Average reported values in Water Quality Reports for Metropolitan Water District Jensen plant (100 percent State Project Water) from 1999 to 2002
2 Average reported values in Water Quality Reports for Metropolitan Water District Weymouth and Diemer plants (61 to 82 percent Colorado River Water blended with SWP water) from 1999 to 2002
3 Average groundwater quality values as reported by CBMWD from 1998 to 2000
4 Average reported values for the San Jose WRP from 1998 to 2000
5 State of California DHS Primary Drinking Water Standard
6 State of California DHS Secondary Drinking Water Standard
7 500 mg/L is recommended TDS level for drinking water, 1,000 mg/L is upper limit
NA Not available

4.0 POTENTIAL BENEFITS

Wide-scale conversion of dye houses within Central Basin would benefit both the dye houses (customer) directly and the entire Southern California region.

4.1 Dye House Customer

The conversion from potable to recycled water supplies offers the dye house three main benefits.

1) Reliability of supply improves dramatically for the industry. With the potable supply, industry customers are subject to mandatory water rationing during times of drought, which can severely impact production. This disruption can result in significant financial losses for the business. Supply reliability increases dramatically when using recycled water because the supply is not affected by drought conditions.

2) The consistency of the water quality improves when using recycled water. Unlike the potable supply, with widely-varying quality depending on the source water, the recycled water quality is very consistent due to the consistency of the wastewater supply. A more consistent water quality reduces the impacts on the dyeing processes and can potentially reduce the need for chemical addition.

3) Within Central Basin the conversion to recycled water offers the significant benefit of reduced water costs. Central Basin wholesales recycled water to local purveyors at approximately 60 percent the cost of potable water. The savings to the end-user can vary in the range of 10 to 35 percent depending on the individual retail agency. With the amount of water used in dye house operations, this reduction in cost can be substantial.

4.2 Societal Benefits

In addition to the benefit to the individual dye house customer there is also a benefit to society as a whole. A decrease in potable water use increases supply reliability for everyone living in Southern California by preserving potable supplies for uses requiring higher quality. Increased recycled water use also allows for increased storage of potable supplies and can reduce the impacts felt during drought conditions or during times of emergency (i.e. earthquakes or wildfires).

Energy savings are another large-scale benefit of increasing recycled water use. The major difference in energy costs between recycled water and potable water is the cost of importing the potable water supply which is transported hundreds of miles. Approximately 50 to 60 percent of the water supplied to Southern California's residents, agriculture and industries is imported. Southern California has minimal local surface water supplies and its groundwater supplies are only able to supply a small portion of the demand. The two main imported water supply aqueducts are the Colorado River Aqueduct and the California Aqueduct (State Water Project). The energy and financial costs to transfer this water are substantial, as indicated in **Table 4**.

Table 4
Energy Required to Convey
Potable Water to Los Angeles County

Source	Energy Requirement (MWH/AF)	Marginal Yearly Energy Cost * ($/AF)
State Water Project – East Branch	3.2	$130
State Water Project – West Branch	2.8	$110
Colorado River	2	$80

* Cost determined using marginal cost of MET power - $0.04/kWh. Source: CBMWD

Use of recycled water produced locally eliminates the need to incur the marginal energy cost associated with the transportation of these potable supplies. Recognizing these energy savings and the need to develop additional water supplies METROPOLITAN offers financial rebates of up to $250 per AF for use of recycled water within its service area.

5.0 POTENTIAL USES IN CENTRAL BASIN MWD SERVICE AREA

Several dye and finishing houses currently operate within the service area of the Central Basin MWD. A summary of these establishments and their estimated potable water use are presented in **Table 5**

Table 5
Estimated Water Usage among Dye Houses in the Central Basin

Dye House	Location	Potable Water Use (AF/yr)
Chris Stone & Associates	Vernon, CA	200
Complete Garment, Inc.	Vernon, CA	50
JDS Finishing	Vernon, CA	650
General Dye & Finishing, Inc.	Santa Fe Springs, CA	500
A's Match Dyeing	Vernon, CA	600
Dynix Textile Corp	Vernon, CA	400
Ni Industries	Vernon, CA	350
TGI Fashion, Inc.	Vernon, CA	100
Tissurama	Vernon, CA	1,100
Zion Textiles	Vernon, CA	200
		TOTAL = 4,150

Note: Dye houses listed are those within the current or future-planned service area for recycled water.
Source: CBMWD

It is estimated that approximately 90 percent of the water usage by these dye houses can be converted to recycled water resulting in a total savings of over 3,700 acre-feet per year.

6.0 ROADBLOCKS TO WIDE-SCALE IMPLEMENTATION

There are several roadblocks to wide-scale conversion of dye houses to recycled water, including the lack of proven success, regulatory concerns and health and safety issues that may be encountered with the use of recycled water.

6.1 Proven Use

A recent survey conducted on recycled water in the fabric dyeing industry resulted in the finding that only one fabric dye house in the United States operates on recycled water; however, this facility uses recycled water that has been treated with reverse osmosis (ED, 2002). Fruit of the Loom operates a large bleach-and-dye facility in Southern Texas. The company built their facility in the water-scarce area in 1988 in part because of a promise for a dependable supply of high quality recycled water. The Harlingen Water Works System supplies the plant with 4.0 mgd of wastewater treated with reverse osmosis. Though the plant has been operating very successfully for 15 years on the recycled water provided, the company is closing the plant on December 31, 2003 and relocating overseas in order to cut costs (Brezosky, 2003).

Despite many indications of the potential success of using recycled water for textile dyeing operations and the low cost of recycled water, there are currently no full-scale recycled water operations of dye houses using Title 22-quality water for their processes. Despite the water intensive nature of the dye process, water is only a fraction of the overall operational cost to the dye house. Existing dye houses operate on a very small financial margin and cannot afford to withstand the cost of a loss if a batch of fabric were damaged or destroyed due to the use of recycled water. Without a full-scale operating dye house most operators are reluctant to use the recycled water.

One attempt at creating a full-scale operation is happening at General Dyeing and Finishing, Inc. (General Dye), a batch dyeing facility located in Santa Fe Springs, California. The facility dyes approximately 30,000 pounds of fabric a day, typically cotton, polyester and cotton/polyester blends, using a total of between 450 and 560 acre-feet of potable water per year.

A one-day pilot test was conducted on October 15, 2002 using recycled water in one of the 12 large dye machines used at the facility. A temporary connection was made using 1-inch hose from an air release on the CBMWD recycled water system directly to the dye machine fill line. General Dye conducted two tests using the recycled water during the pilot—one using reactive dye with a cotton/polyester blend fabric and one using dispersed dye on 100 percent polyester fabric. Both test loads used about 800 pounds of fabric and blue dyes. Identical means and methods of the water softening, scouring, bleaching and dyeing processes used by General Dye with domestic water were followed using recycled water. At the conclusion of the test, the staff did not notice any difference to the dyeing process or the quality of the end product with the recycled water as compared to domestic water.

A one-week demonstration test was conducted from November 20 through 27, 2002 based on the successful results of the pilot test. During this test, a large variety of colors and shades were used, ranging from very light to very dark. Test loads included cotton, polyester and cotton/polyester blended fabrics. As with the pilot test, the exact same methods of dyeing were maintained with the recycled water as would have been done with the domestic water. Once again, the test was a success. No difference in the final fabric colors were noticed, not even with the lighter shades. As a result of these tests, General Dye is planning a full conversion to recycled water in the fall of 2004.

6.2 Regulatory Issues

Regulatory issues involved with the conversion include retrofit concerns and sewer discharge impacts. Retrofit issues involve determining what modifications are required to comply with Title 22 and Title 17 regulations and also to determine who will pay for the cost of the retrofit conversion. Dye houses may not be willing to finance the required retrofits themselves unless they are proven to have a short payback time (less than six months).

Another concern for dye house operators is any potential increase in sewage disposal costs that might result from the higher levels of constituents in dye house effluent caused by the recycled water. However, within Central Basin this should not be an issue since the Los Angeles County Sanitation Districts have instituted a policy whereby industrial users that convert to recycled water pay no additional charges if the higher levels of constituents seen are as a result of the conversion to recycled water.

6.3 Health and Safety Concerns

Dye house managers may have some concerns over safety of their workers once they make the switch to recycled water. The water to be supplied to the facility, however, is certified to be safe for use in industrial applications by the State Department of Health Services. It should also be noted that once water enters the facility, its designation changes to “industrial water” regardless of whether it was originally potable or recycled. As a result of the conversion, the same precautions are to be taken when working with industrial water. There are no new safety concerns for employees when recycled water is in use.

Health and safety issues could also be of concern with regard to the marketing of the product. Dye house managers may be concerned whether there will be negative perception of their product due to the water used during processing. In contrast, however, the positive perception may be more significant due to Southern California's familiarity with recycled water and the benefits felt as a result of its increased use. Carpet dyers that have made the switch currently tout their use of recycled water promoting themselves as an environmentally-conscious business (Pacificrest Mills, 2003).

7.0 FREQUENTLY ASKED QUESTIONS

While wide-scale conversion of dye houses to recycled water is technologically feasible, several issues stand in the way of this goal being reached. The main issues pertain to the reluctance of dye house owners to make the conversion. Owners are leery of making the conversion out of uncertainty over water quality, water quality consistency and supply reliability. To address these issues, sample frequently asked questions by dye house managers are answered below.

Q: *Is the recycled water to be provided of high enough quality for textile dyeing and finishing purposes?*

A: Yes. The quality of the recycled water is on par with the potable supply. As is done with the potable supply, softening agents will need to be added to reduce hardness. To verify that the water will work with your specific processes, contact CBMWD to set up a one-day trial test.

Q: *How consistent is the quality of recycled water?*

A: Because of the relative consistency of the wastewater supply, recycled water quality is quite consistent. In contrast, the potable water supply is much more inconsistent because potable water is supplied from three different sources, each of different quality and at varying quantities.

Q: *How reliable is the supply? What happens if there's an upset in the system and we can't get the water we need?*

A: The recycled water supply is very reliable. Unfortunately, however, temporary upsets or line breaks compromise your supply of water. In this case the supply line to your facility would be switched to the potable supply using the special piping configuration located at your facility.

Q: *What about health and safety concerns? Are my employees safe while working with this water?*

A: The recycled water supplied to your facility is certified by the California Department of Health Services (DHS) to be completely safe for human contact. There are no health and safety concerns associated with the use of this water at your facility. DHS-approved signs will be posted in your facility notifying the public and employees that recycled water is being used. All restrooms, kitchen facilities, safety showers and eye washes will remain on the potable system.

Q: *Are there new regulatory issues associated with this conversion? If so, what types of changes need to be made at my facility in order to accommodate those?*

A: As a result of making this conversion there are only minor changes that will need to be made to your facility. For example, signs will be posted notifying the public and employees that recycled water is in use. An on-site management program setting forth operating procedures and responsibilities will be developed so that cross connections are not made between the potable and recycled water supplies. Finally, a comprehensive response plan will be prepared that details the procedures and actions to be taken in the event of a cross connection.

Q: *Have other dye houses made this conversion? How successful has the conversion been?*

A: No other dye houses have made this specific conversion, although one dye house in Texas has been successfully using reverse osmosis-treated wastewater for 15 years. Numerous studies, including the demonstration test at General Dyeing and Finishing, Inc., have proven the feasibility of using recycled water for dyeing and finishing purposes. The cheap price of potable water and uncertainties over recycled water quality have kept most dye houses from making the conversion in the past.

Q: *What's the cost of this conversion?*

A: This must be determined on a case by case basis for each dye house. However, in most instances the potential savings in the cost of the recycled water allows for a payback on the investment in less than one year.

8.0 CONCLUSION

As demonstrated in this paper, wide-scale conversion of dye houses from potable water to recycled water is very feasible and offers benefits to both the end user and to society as a whole. The recycled water supply meets the quality requirements of the dye houses processes and has been proven to be successful during numerous studies. The dye houses benefit from the conversion with increased supply reliability, improved water quality consistency and reduced water costs. Society benefits with increase potable supply reliability, especially during times of drought. Unfortunately the biggest roadblock to the wide-scale conversion is the lack of proven use. Most fabric dye houses will not make the switch without proof that it works successfully. The conversion of an existing dye house, such as General Dye, is what is needed most to instigate this wide-scale implementation and demonstrate the successful conversion to recycled water.

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